

Implementation Techniques for Transcutaneous Carbon Dioxide Monitoring: Approaches for Wearable Smart Health Applications

Tuna B. Tufan , *Graduate Student Member, IEEE*, Lawrence Rhein,
and Ulkuhan Guler , *Senior Member, IEEE*

Abstract—Wearable smart health applications aim to continuously monitor critical physiological parameters without disrupting patients' daily activities, such as giving a blood sample for lab analysis. For example, the partial pressure of arterial carbon dioxide, the critical indicator of ventilation efficacy reflecting the respiratory and acid-base status of the human body, is measured invasively from the arteries. Therefore, it can momentarily be monitored in a clinical setting when the arterial blood sample is taken. Although a noninvasive surrogate method for estimating the partial pressure of arterial carbon dioxide exists (i.e., transcutaneous carbon dioxide monitoring), it is primarily limited to intensive care units and comes in the form of a large bedside device. Nevertheless, recent advancements in the luminescence sensing field have enabled a promising

confirmed worldwide [2]. Asthma, a lifelong respiratory disease, is responsible for more than 3,500 deaths annually in the United States [3]. The ability to continuously monitor the respiration effectiveness of at-risk patients in real time is critical to preventing acute respiratory failure before it becomes a threat.

The accurate diagnosis of respiratory diseases requires a measure of the partial pressure of arterial oxygen (PaO_2) and the arterial partial pressure of carbon dioxide (PaCO_2) referred to as blood gases [4]. PaCO_2 indicates the efficacy of ventilation, the removal of carbon dioxide from the blood through air exchange in the alveoli, and the acid-based status of the blood [5]. The gold standard for measuring PaCO_2 is an arterial blood gas